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ABSTRACT

This workbook is intended for students enrolled in a 3-day introductory course to electronics developed during a project to retrain defense industry workers at risk of job loss or dislocation because of conversion of the defense industry. The workbook begins with a course outline and is divided into three sections that parallel the following objectives of the course's 3 days: understand atomic structure and electrons, define electronic terms, use electronic prefixes, and practice electrical safety; understand common electronic symbols, draw simple electronic schematics, solve series and parallel Ohm's law problems, and calculate power dissipation; and measure electrical quantities (voltage, current, and resistance), define and troubleshoot shorted and open circuits, discuss magnetic fields and transformer operation, and discuss and demonstrate measuring secondary voltage. Each section contains information sheets and learning activities. A final test is also included. (MN)

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ED 391 906

Introduction to Electronics

Training Workbook

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9 Hour Course Outline

Day One

Study atomic structure and the electron

Define electronic terms
- Voltage
- Current
- Resistance
- Power
- Voltage drop

Use electronic prefixes
- Pico
- Nano
- Micro
- Milli
- Kilo
- Mega

Electrical safety

Day Two

Familiarize with common electronic symbols
- Resistor
- Potentiometer
- Capacitor
- Battery
- A.C. Sine source
- Inductor
- Transformer
- Meter
- Bulb
- Diode

9 Hour Course Outline

Day Two, Continued

Bipolar transitor
F.E.T. transistor

Draw simple electronic schematic

Solve series of Ohm's law problems

Solve parallel Ohm's law problems

Calculate power dissipation

Day Three

Discussion and instructor demo on measuring:
- Voltage
- Current
- Resistance
- Coil and transformer resistance

Define and paper-troubleshoot shorted circuits

Define and paper-troubleshoot open circuits

Discuss magnetic fields

Discuss transformer operation

Discuss and demonstrate measuring secondary voltage

Final test

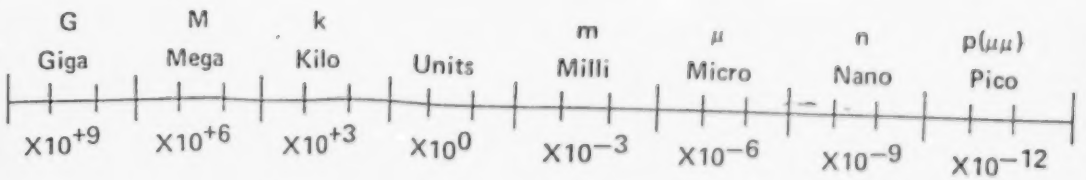
Your Notes

Engineering Notation

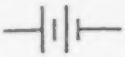
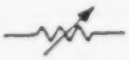
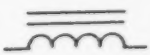
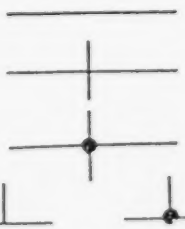
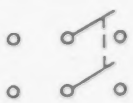
ENGINEERING NOTATION is the rewriting of a number so that the powers of 10 are in multiples 3 and with at least one.two or three whole numbers to the left of the decimal point. These powers of 10 can now be easily converted to prefixes if any unit of measure is used.

Value	Power of 10	Prefix	Symbol
1,000,000,000.	$X10^{+9}$	giga	G
1,000,000.	$X10^{+6}$	mega	M
1,000.	$X10^{+3}$	kilo	k
1.	$X10^{0}$	(units)	–

Value	Power of 10	Prefix	Symbol
.001	$X10^{-3}$	milli	m
.000 001	$X10^{-6}$	micro	μ
.000 000 001	$X10^{-9}$	nano	n
.000 000 000 001	$X10^{-12}$	pico	p($\mu\mu$)



Symbols and Devices

Symbol	Device	Symbol	Device
	Battery or DC Power Supply		Push Button Normally Open (PBNO)
	Resistor		Push Button Normally Closed (PBNC)
	Potentiometer		Earth Ground
	Rheostat		Chassis Ground
	Tapped Resistor		Capacitor
	Meters — Symbol to Indicate Function		Capacitor, Polarized (Electrolytic)
	Lamp		Coil, Air Core
	Switch SPST		Coil, Iron Core
	Switch SPDT		Fuse
	Switch DPST	Conductor, General No Connection	
	Switch DPDT	Connection	

Terminology

TERM	UNIT	SYMBOL	FORMULA	
			SERIES	PARALLEL
Charge	Coulomb	Q	1 coulomb = ~~6.28~~ 6.25 X 10^{18} electrons	
Voltage (Potential difference, EMF)	Volt (V)	E	$E_T = E_1 + E_2 + E_3 + \dots$	$E_T = E_1 = E_2 = E_3 \dots$
Current (Flow of charge)	Ampere (Amp) (A)	I	$I_T = I_1 = I_2 = I_3 \dots$	$I_T = I_1 + I_2 + I_3 \dots$
Resistance	Ohm (Ω)	R	$R_T = R_1 + R_2 + R_3 + \dots$	$R_T = \frac{1}{1/R_1 + 1/R_2 + 1/R_3 + \dots}$ $R_T = \frac{R_1 R_2}{R_1 + R_2}$ $R_T = \frac{R_s}{N}$
Conductance	Mho ($\mho$)	G	$G_T = 1/R_T$	$G_T = G_1 + G_2 + G_3 \dots$
Power	Watt (W)	P	$P = IE$ $P = E^2/R$ $P = I^2R$	$P = IE$ $P = E^2/R$ $P = I^2R$
Capacitance	Farad (F)	C	$C_T = \frac{1}{1/C_1 + 1/C_2 + 1/C_3 + \dots}$	$C_T = C_1 + C_2 + C_3 + \dots$
Inductance	Henry (H)	L	$L_T = L_1 + L_2 + L_3 + \dots$	$L_T = \frac{1}{1/L_1 + 1/L_2 + 1/L_3 + \dots}$

Your Notes

Conversion of Units

4-1. Introduction. a. When you measure the length of a board, you may use a standard unit of measurement called the "foot." And when you measure the weight of an object, you may use another unit of measurement, such as the "pound." So, too, in electricity, when you measure voltage, current, and resistance, you use standard units of measurement. You already know that voltage is measured in volts, current in amperes, and resistance in ohms. The volt, ampere, and ohm are called basic units of measurement.

b. There are times, however, when voltage, current, and resistance values are either too large or so small that basic units are too clumsy to be used practically. So we use a system of prefixes to make the numbers easier to work with. When you solve problems using Ohm's Law, the values of voltage, current, and resistance must be in basic units of measurement. This means that you'll have to convert prefix values of measurement back into basic units.

4-2. Objectives of this chapter. After completing this chapter, you will be able to do the following.

a. State the meaning of the following prefixes: mega, kilo, milli, and micro (frames 1-18).

b. Convert electrical measurements given in prefix values to basic units (frames 19-41).

c. Abbreviate electrical measurements given in prefix values (frames 42-48).

d. Convert electrical measurements given in basic units to prefix values (frames 49-70).

Read down the page.
Start: →
Confirmation: ↓

1. Voltage is measured in _____s.
Current is measured in _____s.
Resistance is measured in _____s.

---

1. volts.
amperes.
ohms.

2. The volt, ampere, and ohm are called the BASIC UNITS of electrical measurement. The three Ohm's Law formulas are given below. Below each formula, write Ohm's Law in basic units.

$E = I \times R$

volts = _____ x _____

$I = \frac{E}{R}$

amperes = _____

$R = \frac{E}{I}$

ohms = _____

---

2. volts = amperes x ohms

amperes = $\frac{\text{volts}}{\text{ohms}}$

ohms = $\frac{\text{volts}}{\text{amperes}}$

3. Sometimes the basic units are either so large or so small that very long numbers must be used. For example, what is the resistance in a circuit if E = 300 volts and I = .0003 ampere.
R = _____ ohms.

Conversion of Units

3. 1,000,000 ohms.

4. Here's another example. E = 6 volts and R = 1,000,000 ohms. Find the current. I = _____ ampere.

4. .000006 ampere

$$I = \frac{E}{R} = \frac{6}{1{,}000{,}000}$$

$$100000 \overline{)\,6.000000}\quad .000006$$

I = .000006 ampere

5. R = 1,000,000 ohms and I = .000006 ampere, are electrical measurements given in basic units. As you can see, the numbers used in these measurements are very clumsy to work with. So we use a system of prefixes to make the numbers easier to work with. Which of these measurements uses a prefix? (R = 1 megohm) (R = 1,000,000 ohms)

5. (R = 1 megohm)

6. A prefix is something (usually two or more letters) that is placed, or fixed, before the basic unit. For example, both of these measurements mean the same thing. Which one uses a prefix? (.000006 ampere) (6 microamperes).

6. (6 microamperes)

7. Look at this list of measurements. Some are in basic units; others use a prefix. Check the measurements that are in basic units.

( ) 50 milliamperes
( ) 10,000 volts
( ) 5 amperes
( ) 10 megavolts
( ) 100 microamperes
( ) 5 kilovolts
( ) 50 ohms

7. (✓) 10,000 volts
(✓) 5 amperes
(✓) 50 ohms

8. Prefixes are used to make measurements easier to work with. Instead of saying "the voltage is 1,000,000 volts," its much handier to say "one megavolt." What is a handier way of saying 2,000,000 volts? _____.

8. 2 megavolts.

9. The table below shows the four most often used prefixes and their meanings. Look at the table. The prefixes you would use to represent large-value numbers are _____ and _____. The prefixes for small-value numbers are _____ and _____.

Prefix	Meaning
mega	1,000,000
kilo	1,000
milli	.001
micro	.000001

Conversion of Units

9. mega
kilo.
milli
micro.

10. You need to know only 4 prefixes in your work. Remember: These prefixes are used with the basic units of electrical measurement. In the list below, locate the prefixes.

Measurement	Prefix
15 megavolts	_____
5 kilovolts	_____
150 milliamps	_____
500 microamps	_____

10. mega
kilo
milli
micro

11. Mega means "million." Thus, a "megaton bomb" is equivalent to one _____ tons of TNT.
Kilo means "thousand." Therefore, a "kilowatt" is equivalent to one _____ watts.

11. million (1,000,000)
thousand (1,000)

12. Mega means _____. Kilo means _____.

12. million (1,000,000)
thousand (1,000)

13. The prefix milli means "one-thousandth." The decimal fraction for one-thousandth is .001. Therefore, a milliampere is what decimal part of an ampere? _____.
The prefix micro means "one-millionth." The decimal fraction for one-millionth is .000001. Therefore, a microampere is what decimal part of an ampere? _____.

13. .001
(one-thousandth)
.000001
(one-millionth)

14. Milli means _____ (use decimal).
Micro means _____ (use decimal).

14. .001
.000001

15. Which is larger, mega or kilo? _____.
Which is smaller, milli or micro ? _____.

15. mega.
micro

16. Here are two lists. One is correct and the other is not. Which list gives the correct meanings of the 4 prefixes? _____.

LIST A	LIST B
mega 1,000,000	mega 1,000,000
micro..... .001	micro..... .000001
kilo ..... .000001	kilo..... 1,000
milli..... 1,000	milli..... .001

Conversion of Units

16. List B
mega ... 1,000,000
micro... .000001
kilo.... 1,000
milli... .001

*17. Identify the prefix that corresponds to each meaning.

MEANING	PREFIX
1,000,000	_____
.000001	_____
1,000	_____
.001	_____

17. mega
micro
kilo
milli

*18. Identify the prefixes.

PREFIX	MEANING
milli	_____
kilo	_____
mega	_____
micro	_____

18. .001
1,000
1,000,000
.000001

19. Many of the values of resistance, current, and voltage you'll see on schematic diagrams will use prefixes. You must understand exactly what they mean. For example, the high voltage in a certain TV receiver is given as 16 kilovolts or 16 kv. Now, one kilovolt equals 1,000 volts. Therefore, 16 kilovolts (16 kv) equals _____ volts.

19. 16,000 volts

20. The resistance of a circuit on the schematic of a radio set is given as 3 megohms. One megohm equals 1,000,000 ohms. Therefore, 3 megaohms equals _____ ohms.

20. 3,000,000 ohms.

21. The radar signal "bounced" off a target comes back as a "radar pip." The strength or amplitude of the pip in a certain radar set is given as 5 microvolts. Now, 1 microvolt equals .000001 volt. Therefore, 5 microvolts equals _____ volt.

21. .000005 volt.

22. The current in a certain circuit is given as 8 milliamperes. One milliampere equals .001 ampere. Therefore 8 milliamperes equals _____ ampere.

22. .008 ampere.

23. To convert prefix values such as kilovolts, megohms, microvolts, and milliamperes to basic units, you must (multiply) (divide) by the prefix meaning.

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Conversion of Units

23. (multiply)

24. This table shows you how to convert prefix values to basic units.

TO CONVERT	MULTIPLY BY
mega	1,000,000
kilo	1,000
milli	.001
micro	.000001

Use the table to convert chese prefix values to basic units.

5 microamperes = _____amperes
10 kilovolts = _____volts
6 megohms = _____ohms
9 milliamperes = _____amperes.

---

24. .000005
(5 x .000001)
10,000
(10 x 1,000)
6,000,000
6 x 1,000,000)
.009 (9 x .001)

25. Now change these prefix values to basic units. You fill in the blanks.

TO CONVERT	MULTIPLY BY	TO GET
10 milliamperes	.001	_____amperes
50 kilovolts	1,000	_____volts
25 megohms	1,000,000	_____ohms
6 microamperes	.000001	_____amperes

---

25. .010
50,000
25,000,000
.000006

26. Fill in the middle column of blanks.

TO CONVERT	MULTIPLY BY	TO GET
3 microamperes	_____	.000003 ampere
5 megohms	_____	5,000,000 ohms
2 milliamperes	_____	.002 ampere
4 kilovolts	_____	4,000 volts

---

26. .000001
1,000,000
.001
1,000

27. Fill in the blanks below.

PREFIX	MULTIPLIER
milli	_____
micro	_____
kilo	_____
mega	_____

---

27. .001
.000001
1,000
1,000,000

28. Convert these prefix values into basic units.

15 milliamperes = _____amperes
25 megohms = _____ohms
50 microamperes = _____amperes
75 kilovolts = _____volts

Conversion of Units

28. .015
25,000,000
.000050
75,000

29. Look at this list of measurements. Notice that the measurements given in basic units have (more)(less) digits than those given in prefix form. Therefore, when prefixed values are converted to basic units, the result is (longer)(shorter).

PREFIX VALUE	BASIC UNITS
1 milliampere	.001 ampere
1 microampere	.000001 ampere
1 kilovolt	1,000 volts
1 megohm	1,000,000 ohms

29. (more)
(longer).

30. Select the correct basic units in this list of measurements.

PREFIX VALUE		BASIC UNITS
1 megavolt	=	(.000001 volt)(1,000,000 volts)
1 milliampere	=	(.001 ampere)(1,000,000 amperes)
1 kilohm	=	(.001 ohm)(1,000 ohms)
1 microampere	=	(.000001 ampere)(.001 ampere)

30. (1,000,000 volts)
(.001 ampere)
(1,000 ohms)
(.000001 ampere)

31. Most measurements stated in whole numbers are given without a decimal point as in measurement a below. The decimal point is left off for the sake of convenience. Which sets of measurements below have the same meaning? _____.

Set 1: a. 3 milliamperes
b. 3. milliamperes

Set 2: c. .3 milliamperes
d. 3 milliamperes

Set 3: e. 5. kilovolts
f. .5 kilovolts

Set 4: g. 10. megohms
h. 10 megohms

31. Set 1 and Set 4

32. Suppose you had to convert 5 milliamperes to basic units. An easy way to make the conversion is to move the decimal point, like this: 5 milliamperes = .005. amperes. Now you move the decimal point to convert the measurement below to basic units. Add zeros when necessary. 9 milliamperes = _____ampere.
How many places did you have to move the decimal point?
_____places.

32. .009.ampere
3 places.

33. Here's another example: 3 kilovolts = 3,000. volts.
Now you move the decimal point: 10 kilovolts = _____volts.
How many places did you move the decimal point? _____places.

33. 10,000.
3 places.

34. The number of places you move the decimal point depends on the prefix meaning. For example: 7 microamperes = .000007. ampere. Now you convert this measurement:
3 microamperes = _____ampere. How many places did you move the decimal point? _____places.

Conversion of Units

34. .000003.
6 places.

35. When converting measurements given in prefix values to basic units, always move the decimal point in a direction to make the measurement longer. For example: 2 megohms = 2.000000. ohms. Now you convert this measurement: 80 megohms = _____ohms. How many places did you move the decimal point? _____places.

35. 80.000000.
6 places.

36. How many places was the decimal point moved in the following?

a.	.13 kilovolts	= 130 volts	_____places
b.	25 microvolts	= .000025 volts	_____places
c.	60 milliamperes	= .060 amperes	_____places
d.	.50 megohms	= 500,000 ohms	_____places
e.	50 megohms	= 50,000,000 ohms	_____places
f.	13 kilovolts	= 13,000 volts	_____places
g.	.25 microvolts	= .00000025 volts	_____places
h.	.03 millivolts	= .00003 volts	_____places

36. a. 3
b. 6
c. 3
d. 6
e. 6
f. 3
g. 6
h. 3

37. When you see the prefixes below, how many places and in which direction do you move the decimal to convert to basic units?

Prefix	Move the decimal point
micro	_____places to the _____.
kilo	_____places to the _____.
mega	_____places to the _____.
milli	_____places to the _____.

37. 6 left.
3 right.
6 right.
3 left.

38. Remember, when you move the decimal point, the resultant number usually gets longer (has more digit spaces). Here are some more conversions to make. Remember to start at the decimal point.

a.	.65 megohms	=	_____ohms
b.	1,500 microamperes	=	_____amperes
c.	30 kilovolts	=	_____volts
d.	.6 milliamperes	=	_____amperes
e.	2.55 megavolts	=	_____volts
f.	10.5 microvolts	=	_____volts

38. a. 650,000
b. .001500
c. 30,000
d. .0006
e. 2,550,000
f. .0000105

*39. Convert these measurements to basic units.

a.	1.62 milliamperes	=	_____ampere
b.	.333 megohms	=	_____ohms
c.	50.5 microvolts	=	_____volts
d.	15.5 kilohms	=	_____ohms
e.	3.30 milliamperes	=	_____ampere

Conversion of Units

39. a. .00162
b. 333,000
c. .0000505
d. 15,500
e. .00330

40. We use prefixes to make numbers easier to handle. We also use abbreviations to make the prefixes easier to write. For example, the abbreviated forms of words such as microampere and milliampere are: ua (u = micro; a = ampere); and ma (m = milli; a = ampere). If K stands for kilohms, how would you abbreviate 10 kilohms? _____.

40. 10 K

41. The prefix values of electrical measurements with their abbreviations are given below. Which two abbreviations do not include the basic unit? _____ and _____.

PREFIX	ABBREVIATION
milliampere	ma
microampere	ua
megohm	Meg
kilohm	K
kilovolt	kv

41. Meg
K

42. The abbreviations "Meg" and "K" are used by themselves only when the measurement involves ohms. Thus, 25 megohms can be abbreviated to _____ and 10 kilohms can be abbreviated to _____.

42. 25 Meg
10 K

43. Determine the abbreviations for these measurements:
(a) 25 microamperes: _____; (b) 10 kilovolts: _____;
(c) 250 milliamperes: _____; (d) 100 kilohms: _____;
(e) 3 megohms: _____.

43. (a) 25 ua;
(b) 10 kv;
(c) 250 ma;
(d) 100 K;
(e) 3 Meg.

44. The resistance in a circuit is 10 kilohms, abbreviated, 10 _____ and the current is 25 milliamperes, abbreviated, 25 _____. What is the voltage? (Convert to basic units and use Ohm's Law: E = IR)

44. K
ma
250 volts

45. Current in a circuit is 10 milliamperes, abbreviated 10 _____ and the voltage is 1 kilovolt, abbreviated 1_____. What is the resistance of the circuit in basic units? _____ ohms.

Conversion of Units

45. ma
kv
100,000 ohms.
(or 100 K)

Solution: $R = \frac{E}{I}$

$= \frac{1 \text{ kv}}{10 \text{ ma}}$

$R = \frac{1 \times 1000}{10 \times .001} = \frac{1000}{.01}$

or $R = \frac{1000.}{.010.} = \frac{1000}{.01}$

R = 100,000

*46. What are the abbreviations for the following?

300 microamperes = _____
100 kilohms = _____
.5 kilovolts = _____
40 milliamperes = _____
20 megohms = _____

---

46. 300 ua
100 K
.5 kv
40 ma
20 Meg

47. Prefixes are used to make numbers like 10,000 ohms or .000009 amperes easier to handle. Give the number that each of the prefixes below stands for.

a. micro _____ c. mega _____
b. kilo _____ d. milli _____

---

47. a. .000001
b. 1,000
c. 1,000,000
d. .001

48. To convert 10 K to ohms, you multiply by 1,000. However, to change 10,000 ohms to K, you must (multiply)(divide) by 1,000. Thus, 10,000 ohms = _____K.

---

48. (divide)
10 K

49. To convert basic units to prefix values, you must divide. Use the chart below to convert the following measurements to prefix values:

a. .000005 amperes = _____ua. c. .003 amperes = _____ma.
b. 4,000 volts = _____kv. d. 3,000,000 ohms = _____Meg.

TO GET	DIVIDE BY
mega	1,000,000
kilo	1,000
milli	.001
micro	.000001

---

49. a. 5
b. 4
c. 3
d. 3

50. To convert prefix values, such as Meg, K, ua, or ma, to basic units, you must (multiply)(divide). But to convert basic units to previx values, you must _____.

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Conversion of Units

50. (multiply).
divide

51. To convert .015 amperes to milliamperes, you must divide by .001. Therefore, .015 amperes = _____ ma.
But to convert .015 amperes to microamperes, you must divide by .000001. Hence, .015 amperes = _____ ua.

51. 15 ma.
15,000 ua.

52. To convert 500 volts to kilovolts, you must divide by 1,000. Therefore, 500 volts = _____ kv.
But to convert 500 volts to megavolts, you must divide by 1,000,000. Therefore, 500 volts = _____ megavolts.

52. .5 kv
.0005 megavolts.

53. Remember: The prefixes are placed before the basic units of electrical measurement. What are the correct prefixes for the following?

a. 15,000 ohms = 15 _____
b. .005 volts = 5 _____
c. 3,000,000 ohms = 3 _____
d. .000008 amperes = 8 _____

53. a. K (kilohms)
b. millivolts (mv)
c. Meg (megohms)
d. microamperes (ua)

54. Which numbers would you use?

TO CONVERT	TO	DIVIDE BY
amperes	ma	_____
ohms	K	_____
volts	kv	_____
amperes	ua	_____
ohms	Meg	_____

54. .001
1,000
1,000
.000001
1,000,000

55. The resistance of a circuit is 250,000 ohms. How many megohms is this? _____ Meg. How many kilohms is this same resistance? _____ K.

55. .25 Meg.
250 K.

56. The current in a circuit is .0075 amperes. How many milliamperes is this? .0075 a = _____ ma. How many microamperes is this? .0075 a = _____ ua.

56. 7.5 ma.
7,500 ua.

*57. Convert the measurements in column A to their prefix values in column B.

COLUMN A	COLUMN B
.054a	_____ ua
100 v	_____ kv
1,500 ohms	_____ Meg
1,250 ohms	_____ K
25a	_____ ma

Conversion of Units

57. 54,000 ua
.1 kv
.0015 Meg
1.25K
25,000 ma

(If you did not miss any conversion above, read summary.
If you missed any conversion, go on to next frame.)

58. Another way of converting basic units to prefix values is by moving the decimal point, like this: .005 a = .005. = 5 ma. Now, following this example, you move the decimal point to convert the following measurement to a prefix value: .155 a = _____ ma.

In which direction did you more the decimal point, right or left? _____. How many places did you have to move the decimal point? _____ places.

---

58. 155 ma.
right.
3

59. Here's another example: .000005 a = .000005. = 5 ua. Now, you move the decimal point in this example: .0045 a = _____ ua.

In which direction did you move the decimal point? _____.
How many places did you move the decimal point? _____ places.

---

59. 4,500 ua.
right.
6

60. Here's another example showing you how to convert basic units to a prefix value: 1,500 ohms = 1.500. = 1.5 K. Now convert these measurements.

150 ohms = _____ K
16,000 volts = _____ kv

In which direction did you move the decimal point? _____.
How many places did you move it? _____ places.

---

60. .150 K
16 kv
left.
3

61. Now look at this example showing you how to convert basic units to a prefix value: 5,000 ohms = .005000. = .005 Meg. Convert these measurements to prefix values.

350,000 volts = _____ megavolts
4,250,000 ohms = _____ Meg

In which direction did you move the decimal point? _____.
How many places did you move it? _____ places.

---

61. .35 megavolts
4.25 Meg
left.
6

62. Look at this list of conversions. Write the direction and number of places the decimal point has been moved to get the prefix value.

BASIC UNITS	PREFIX VALUES	DIRECTION	PLACES
a. 130 volts	.13 kv	_____	_____
b. .000025 volts	25 uv	_____	_____
c. .060 a	60 ma	_____	_____
d. 550,000 ohms	.55 Meg	_____	_____
e. .00000025 a	.25 ua	_____	_____
f. .00003 a	.03 ma	_____	_____

Conversion of Units

62. a. left 3
b. right 6
c. right 3
d. left 6
e. right 6
f. right 3

63. When converting basic units to prefix values, the direction and number of places you move the decimal point depends on the prefix used. For example:

.000007. a = 7 ua
.007. a = 7 ma

7,000,000 ohms = 7 Meg
7,000 ohms = 7 K

Therefore, when converting basic units to micro and milli prefix values, you move the decimal to the _____.

But when converting to mega and kilo prefix values, you move the decimal to the _____.

63. right.
left.

64. Fill in these blanks.

To Get This Prefix Value	Move the Decimal To	This Number of Places
kilo	_____	_____
micro	_____	_____
milli	_____	_____
mega	_____	_____

64. kilo left 3
micro right 6
milli right 3
mega left 6

65. REMEMBER

1. When converting to milli and micro values, move decimal point to the RIGHT.

2. When converting to mega and kilo values move decimal point to the LEFT.

Now make the volloving Conversions.

.850 volts = _____ uv
.03 amps = _____ ma
900,000 ohms = _____ Meg
950 ohms = _____ K

65. 850,000 uv
30 ma
.9 Meg
.95 K

66. Here are some more conversions to make. Remember to start at the decimal point.

a. 650,000 ohms = _____ Meg
b. .0015 amps = _____ ua
c. 30,000 volts = _____ kv
d. .0006 amps = _____ ma
e. 2,550,000 volts = _____ megavolts
f. .0000105 volts = _____ uv

66. a. .65 Meg
b. 1,500 ua
c. 30 kv
d. .6 ma
e. 2.55 megavolts
f. 10.5 uv

67. Convert these measurements to prefix values.

.0005 volts = _____ uv
250,000 ohms = _____ Meg
500 volts = _____ kv
.25 amps = _____ ma

Conversion of Units

67. 500 uv
.25 Meg
.5 kv
250 ma

*68. Convert these measurements.

.00162 amps = _____ ma
333,000 ohms = _____ Meg
.0000505 volts = _____ uv
15,500 ohms = _____ K
3 amps = _____ ma

68. 1.62 ma
.333 Meg
50.5 uv
15.5 K
3000 ma

NOW READ THE SUMMARY

Then take the self test

4-3. Summary. a. The basic units of electrical measurements are the ampere for current, the volt for voltage, and the ohm for resistance. Sometimes the basic units are either so large or so small that large numbers of digits must be used. These numbers are too clumsy to be practical. So we use a system of prefixes to make the numbers easier to handle. The following chart lists the four prefixes used with the basic units of electrical measurement and their meanings.

PREFIX	MEANING
mega	1,000,000
kilo	1,000
milli	.001
micro	.000001

b. There are two ways to convert prefix values to basic units.

(1) Multiply the prefix value by the prefix meaning.

(2) Move the decimal point an appropriate numbaer of places, depending on the prefix meaning.

c. We use prefixes to make numbers easier to handle. We also use abbreviations to make the prefixes easier to write. This chart lists the prefixes and their abbreviations.

PREFIX	ABBREVIATION
milli	m
micro	u
kilo	k
kilohm	K
megohm	Meg

d. There are two ways to convert basic units to prefix values.

(1) Divide the basic unit by the prefix meaning.

(2) Move the decimal point. The direction and number of places to move the decimal point depend on the prefix meaning.

Conversion of Units

4-4. Conversion of units self-test. a. Fill in the meanings of these prefixes.

(1) kilo = _____

(2) micro = _____

(3) milli = _____

(4) mega = _____

b. How many ohms does 6.5 megohms equal? _____ ohms.

c. Change 850 microamperes to amperes: _____ amperes.

d. Change .25 kilovolts to volts: _____ volts.

e. Change 1.5 milliamperes to amperes: _____ amperes.

f. A current of 15 milliamperes flows through a 47K resistor. The voltage drop across this resistor is _____ volts.

g. The voltage drop across a 2 Meg resistor is 5 volts.

How much current flows through this resistor? _____ ampere, which equals _____ ua.

h. The voltage drop across a certain resistor is .2 kilovolt and the current through it is 100 milliamperes. What is the value of the resistor? _____ ohms.

4-5. Conversion of units self-test answers. a. Fill in the meanings of these prefixes.

(1) kilo = 1,000

(2) micro = .000001

(3) milli = .001

(4) mega = 1,000,000

b. How many ohms does 6.5 megohms equal? 6,500,000 ohms.

c. Change 850 microamperes to amperes: .000850 amperes.

d. Change .25 kilovolts to volts: 250 volts.

e. Change 1.5 milliamperes to amperes: .0015 ampere.

f. A current of 15 milliamperes flows through a 47K resistor. The voltage drop across this resistor is 705 volts.

g. The voltage drop across a 2 Meg resistor is 5 volts. How much current flows through this resistor? .0000025 ampere, which equals 2.5 ua.

h. The voltage drop across a certain resistor is .2 kilovolts and the current through it is 100 milliamperes. What is the value of the resistor? 2,000 ohms.

i. The resistance of a certain circuit is 44K and the current is 6 ma. What is the applied voltage? 264 volts.

j. Convert these electrical measurements.

BEST COPY AVAILABLE

Your Notes

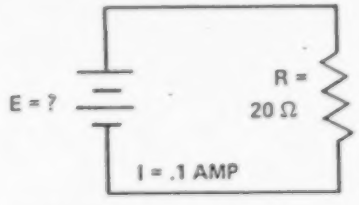
Voltage, Current & Resistance

The following problems are designed to begin to familiarize you with circuits, Ohm's law in very basic cases, and to provide lots of practice in interpreting the resistor color code. Fold over the page... to check on your results.

1. Draw in the space provided below a schematic diagram of a complete circuit containing:

   a. a 10-volt battery
   b. a 100-ohm resistor
   c. all necessary connections (label all components as necessary)

2. In the following circuit a current of 1/10 amp is flowing. Using the basic Ohm's law and power formulas calculate:



   a. The value of the applied voltage

      E = _____ volts.

   b. The power dissipated by the resistor in this circuit

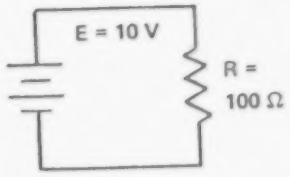
      P = _____ watts

   c. If you were building this circuit, what power rating resistor would you select?

      _____ watt.

Answers

1.

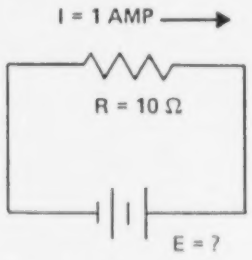


2.a. E = 2 volts

2.b. P = .2 watt

2.c. .4 watt
you would probably
select a 1/2 watt
carbon resistor

3. In the following circuit 1 amp is flowing through the resistor.



a. Calculate the applied voltage E = _____ volts

b. If you wanted 2 amps to flow in this circuit with this same applied voltage, what should the resistance be changed to?

R = _____ ohms

c. If you wanted 2 amps to flow through the 10-ohm resistor you had initially, what should the voltage be changed to?

E = _____ volts

4. In a certain circuit situation you need a 91-ohm 5%-tolerance resistor that is set up to carry .01 amp of current.

a. What is the color code of this resistor?

_____ _____ _____ _____

b. What voltage must be applied to it to yield a .01 amp current flow?

c. Draw a complete schematic of the circuit needed to apply the above voltage to this resistor yielding the .01 amp of current flow?

Answers

3.

3.a. E = 10 volts

3.b. R = 5 Ω

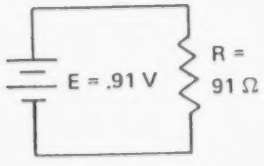
3.c. E = 20 volts

4.

4.a. white, brown, black, gold

4.b. .91 volt

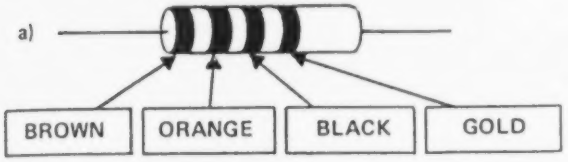
4.c.



4. d. What power rating should the resistor you select have in this circuit?

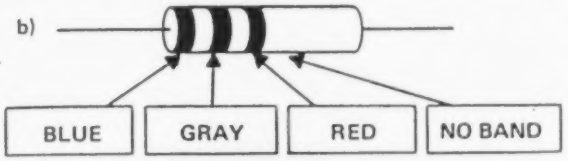
5. To really learn the resistor color code, there's no substitute for the old standby, PRACTICE. Shown below are the codes for common resistors you'll be using in the laboratory. When you can write any resistor's value from its code without looking at your chart, you'll have achieved a major objective of this lesson. Fold over the page to check your answers.

a)



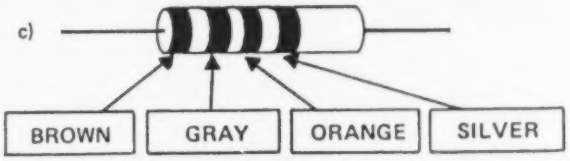
= 5.a. _____ ± _____

b)



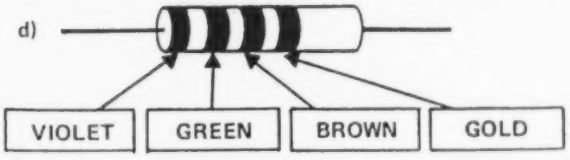
= 5.b. _____ ± _____

c)



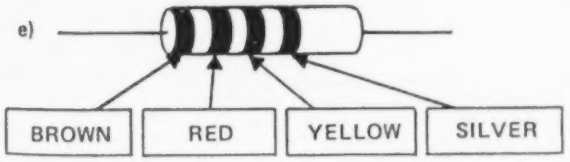
= 5.c. _____ ± _____

d)



= 5.d. _____ ± _____

e)



= 5.e. _____ ± _____

Answers

4.d. The resistor needs to dissipate .0091 watt.
Two times this is .0182 watt.
Select a 1/4 watt resistor.

5.

5.a. 13 Ω ± 5%

5.b. 6800 Ω ± 20%

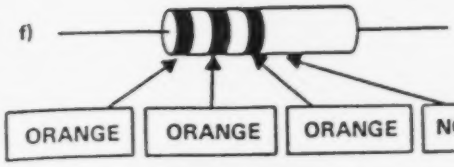
5.c. 18,000 Ω ± 10%

5.d. 750 Ω ± 5%

5.e. 120,000 Ω ± 10%

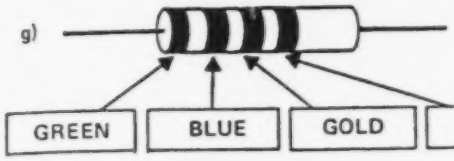
Voltage, Current & Resistance

5. f)



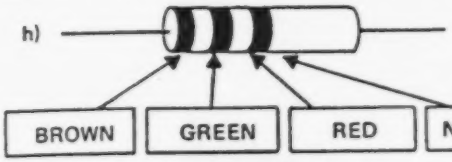
= 5.f. _____ ± _____

g)



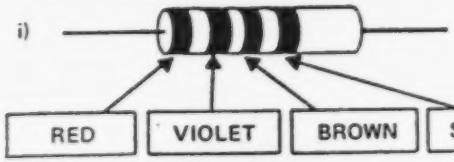
= 5.g. _____ ± _____

h)



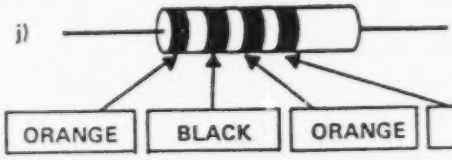
= 5.h. _____ ± _____

i)



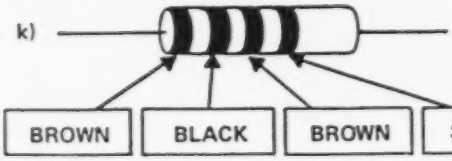
= 5.i. _____ ± _____

j)



= 5.j. _____ ± _____

k)



= 5.k. _____ ± _____

Answers

5.f. 33,000 Ω ± 20%

5.g. 5.6 Ω ± 5%

5.h. 1500 Ω ± 20%

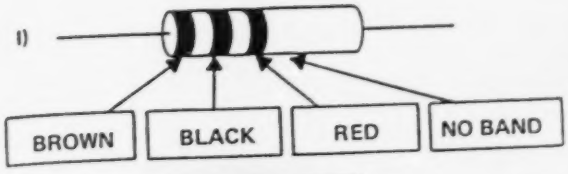
5.i. 270 Ω ± 10%

5.j. 30,000 Ω ± 5%

5.k. 100 Ω ± 10%

Voltage, Current & Resistance

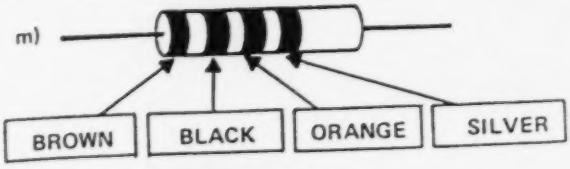
5. l)



=

5.l. _____ ± _____

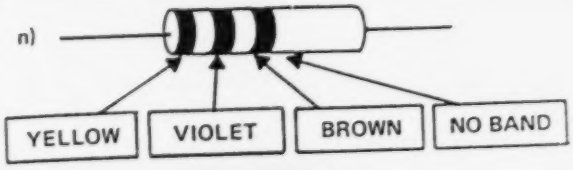
m)



=

5.m. _____ ± _____

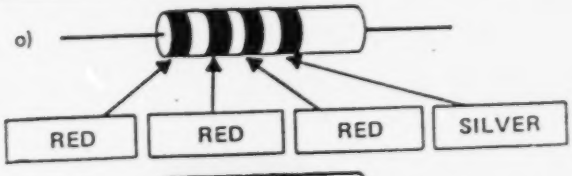
n)



=

5.n. _____ ± _____

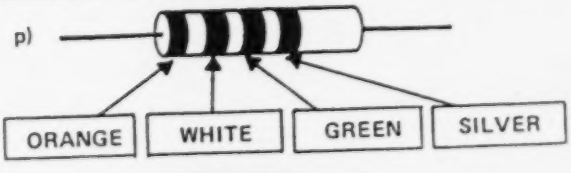
o)



=

5.o. _____ ± _____

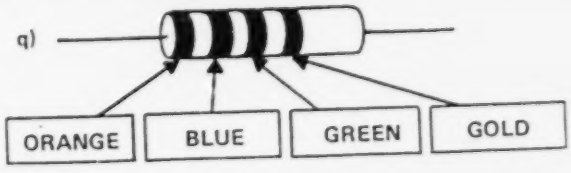
p)



=

5.p. _____ ± _____

q)



=

5.q. _____ ± _____

Answers

5.l. 1000 Ω ± 20%

5.m. 10,000 Ω ± 10%

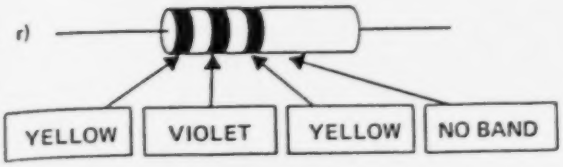
5.n. 470 Ω ± 20%

5.o. 2200 Ω ± 10%

5.p. 3,900,000 Ω ± 10%

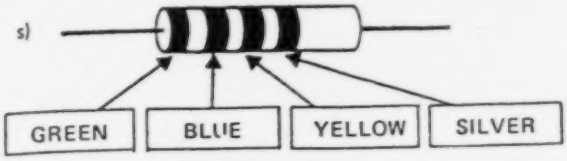
5.q. 3,600,000 Ω ± 5%

5. r)



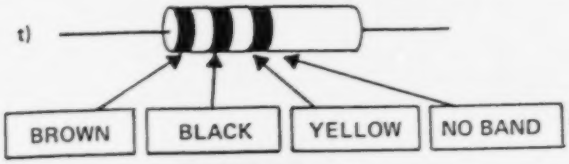
= 5.r. _____ ± _____

s)



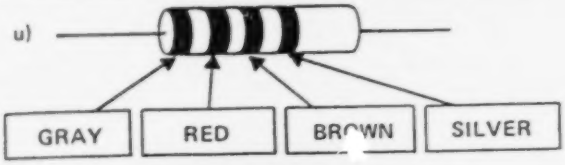
= 5.s. _____ ± _____

t)



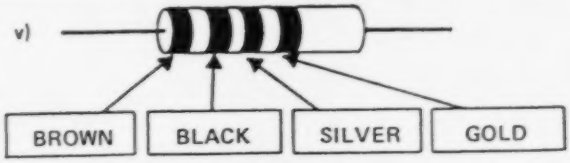
= 5.t. _____ ± _____

u)



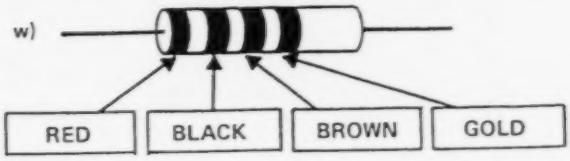
= 5.u. _____ ± _____

v)



= 5.v. _____ ± _____

w)



= 5.w. _____ ± _____

Answers

5.r. 470,000 Ω ± 20%

5.s. 560,000 Ω ± 10%

5.t. 100,000 Ω ± 20%

5.u. 820 Ω ± 10%

5.v. .1 Ω ± 5%

5.w. 200 Ω ± 5%

6. As mentioned it will be important for you to be able to select resistors for use in circuits, given their value in ohms. For each of the resistor values and tolerances indicated below label the color bands that the resistor would have. Fold over the page half way to check your answers.

a. 1500 Ω ± 5%

b. 330,000 Ω ± 20%

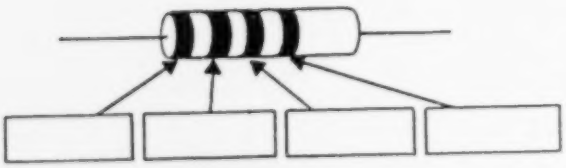
c. 7,500,000 Ω ± 10%

d. 22 Ω ± 5%

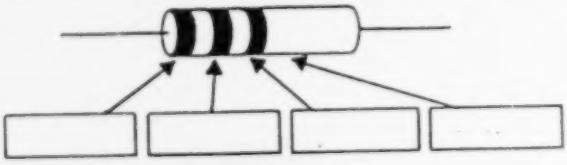
e. 470 Ω ± 10%

6.

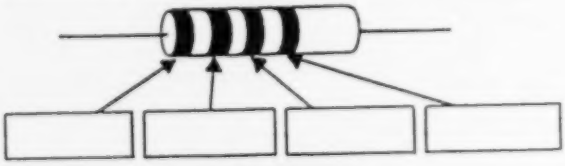
6.a.



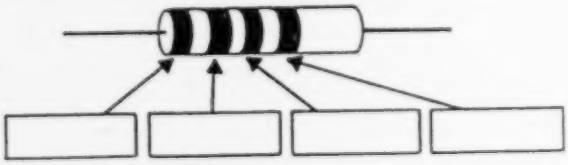
6.b.



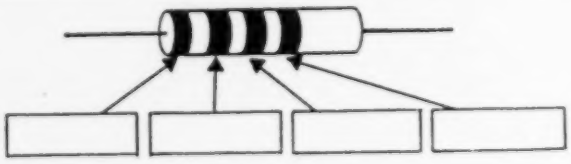
6.c.



6.d.



6.e.



Answers

6.

6.a. brown, green, red, gold

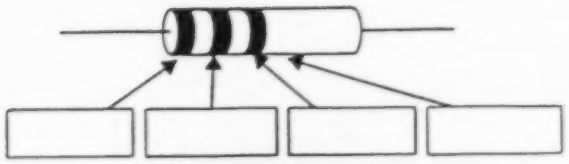
6.b. orange, orange, yellow, no band

6.c. violet, green, green, silver

6.d. red, red, black, gold

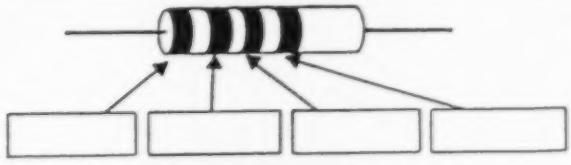
6.e. yellow, violet, brown, silver

6. f. 68,000 Ω ± 20%



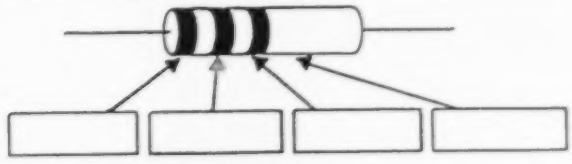
6.f.

g. 120 Ω ± 10%



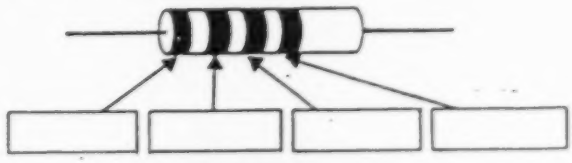
6.g.

h. 1,000,000 Ω ± 20%



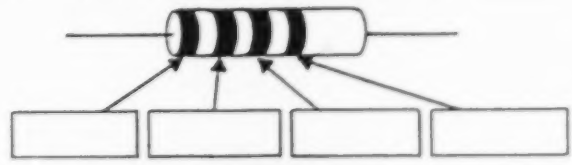
6.h.

i. 1,000,000 Ω ± 10%



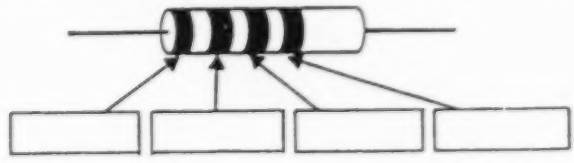
6.i.

j. 5,100 Ω ± 5%



6.j.

k. 820,000 Ω ± 10%



6.k.

Answers

6.f. blue, gray, orange, no band

6.g. brown, red, brown, silver

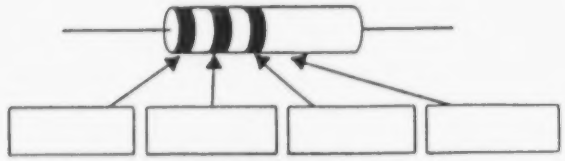
6.h. brown, black, green, no band

6.i. brown, black, green, silver

6.j. green, brown, red, gold

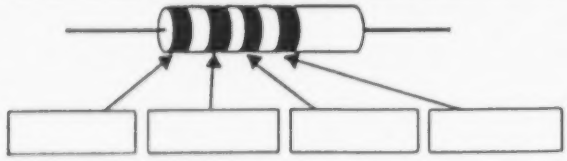
6.k. gray, red, yellow, silver

6. l. 33,000 Ω ± 20%



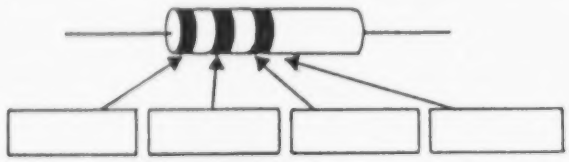
6.l.

m. 27,000 Ω ± 5%



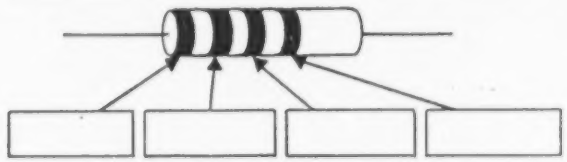
6.m.

n. 22 Ω ± 20%



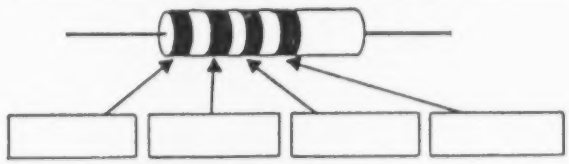
6.n.

o. 1 Ω ± 5%



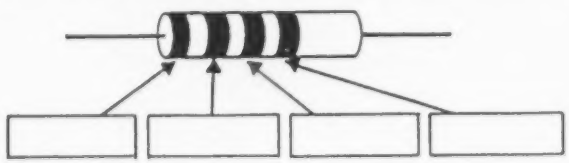
6.o.

p. 8.2 Ω ± 10%



6.p.

q. 560 Ω ± 10%



6.q.

Answers

6.l. orange, orange, orange, no band

6.m. red, violet, orange, gold

6.n. red, red, black, no band

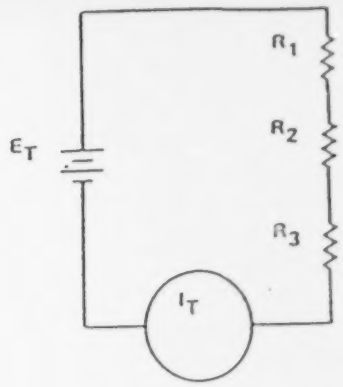
6.o. brown, black, gold, gold

6.p. gray, red, gold, silver

6.q. green, blue, brown, silver

Your Notes

Practice Problems



	E	I	R
R_1			100Ω
R_2			200Ω
R_3			600Ω
TOTALS	9V		

① I - PATHS

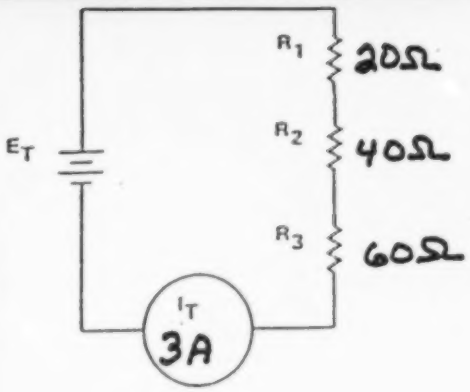
② V - POLARITIES

③ MUST HAVE 2 VALUES

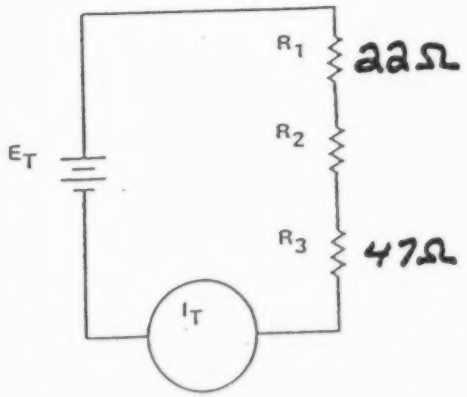
	E	I	R
R_1			5Ω
R_2			10Ω
R_3			15Ω
TOTALS		.5A	

	E	I	R
R_1			2Ω
R_2			5Ω
R_3		3A	
TOTALS	24V		

Practice Problems

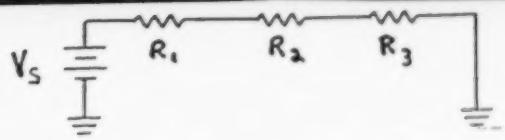


	E	I	R	P
R_1				
R_2				
R_3				
TOTALS				



	E	I	R	P
R_1	11V			
R_2				
R_3				
TOTALS	60V			

Practice Problems

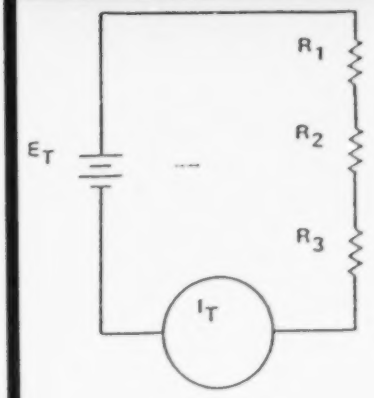


	E	I	R
R_1			4.7k
R_2		3.3 mA	
R_3	8.91		
TOTALS	27.0		
	V	A	Ω

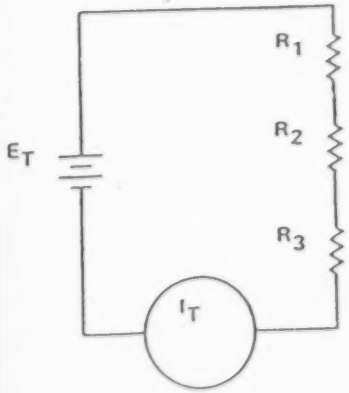
	E	I	R
R_1	10		1K
R_2			2.2k
R_3	36V		
TOTALS			
	V	A	Ω

	E	I	R
R_1	3.0	.2	
R_2			22
R_3			
TOTALS			70
	V	A	Ω

Practice Problems

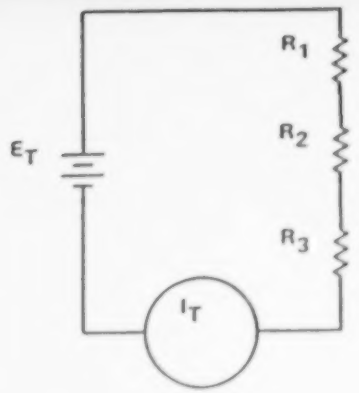


	E	I	R	P
R_1	20V			4.4W
R_2			150Ω	
R_3				
TOTALS	90V			



	E	I	R	P
R_1		.25A		
R_2			330Ω	
R_3	55V			
TOTALS				63.8W

Practice Problems



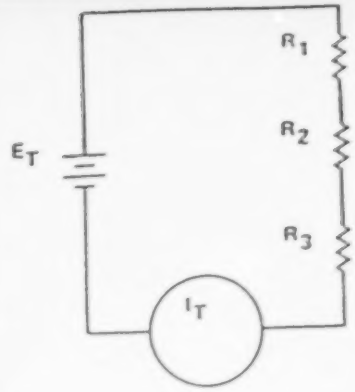
	E	I	R
R_1			5Ω
R_2			10Ω
R_3			15Ω
TOTALS	120V		

1. I PATHS
2. POLARITIES
3. MUST HAVE 2 VALUES

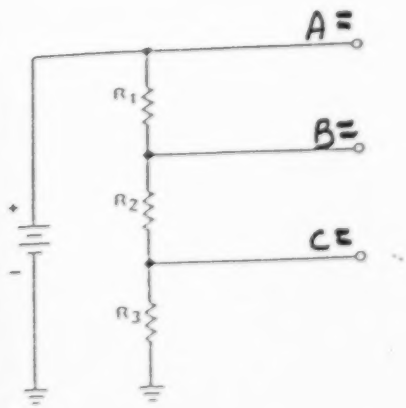
	E	I	R
R_1			2Ω
R_2			5Ω
R_3			3Ω
TOTALS		2A	

	E	I	R
R_1			100
R_2			200
R_3		10A	600
TOTALS			

Practice Problems

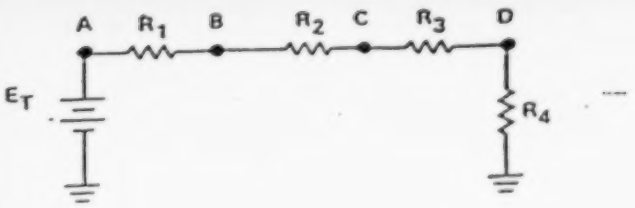


	E	I	R	P
R_1			20Ω	
R_2			40Ω	
R_3			30Ω	
TOTALS		2A		



	E	I	R	P
R_1			100Ω	
R_2			300Ω	
R_3			500Ω	
TOTALS	60V			

Practice Problems



	E	I	R
R_1			10Ω
R_2			25Ω
R_3			15Ω
R_4			5Ω
TOTALS	110V		

V_A _____

V_{AB} _____

V_{BC} _____

V_{CD} _____

V_D _____

	E	I	R
R_1			2kΩ
R_2			4kΩ
R_3			3kΩ
R_4			5kΩ
TOTALS		2mA	

2mA ↑

V_A _____

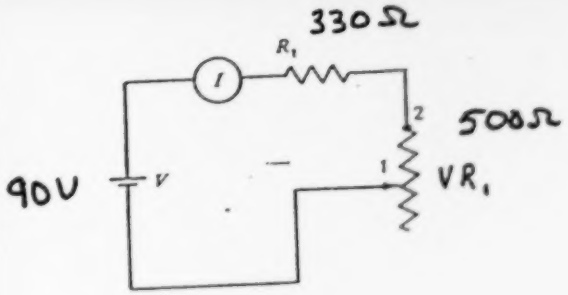
V_{AB} _____

V_{BC} _____

V_{CD} _____

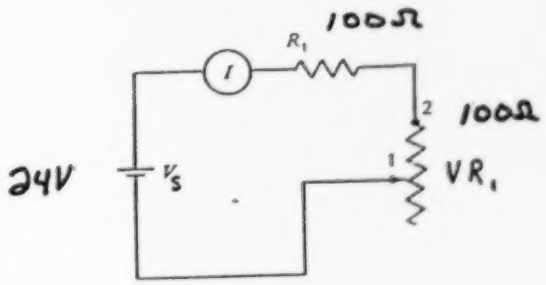
V_D _____

Practice Problems



I MIN =

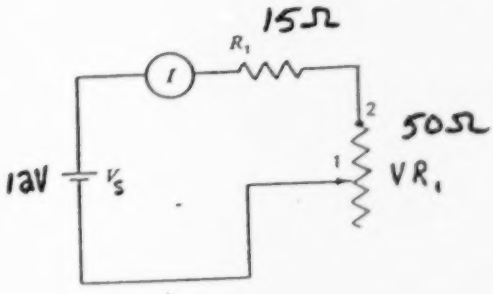
I MAX =



VARY VR1 IN 20Ω STEPS

I MAX = ____

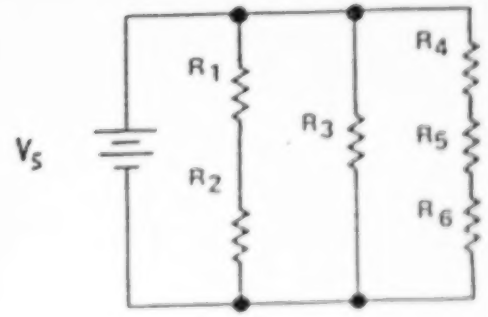
I MIN = ____



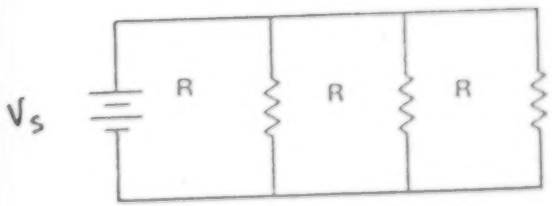
I MIN ____

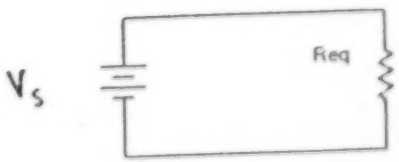
I MAX ____

Practice Problems

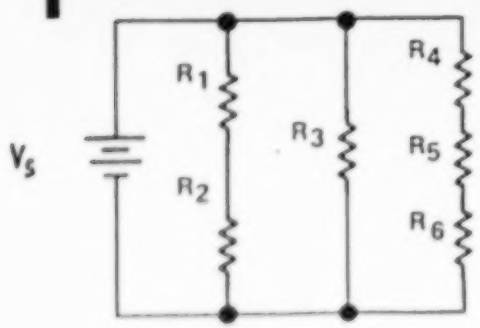


E	I	R
E_{R1}	I_{R1}	R_1 120Ω
E_{R2}	I_{R2}	R_2 330Ω
E_{R3}	I_{R3}	R_3 470Ω
E_{R4}	I_{R4}	R_4 80Ω
E_{R5}	I_{R5}	R_5 40Ω
E_{R6}	I_{R6}	R_6 150Ω
E_T 12V	I_T	R_T

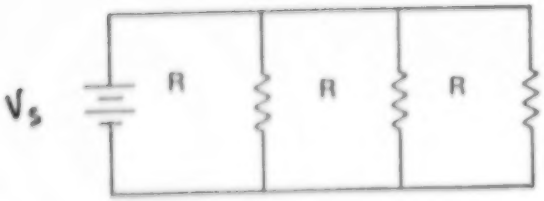


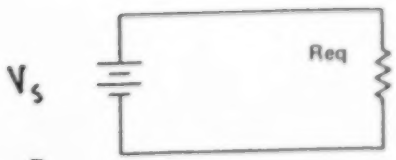


Practice Problems

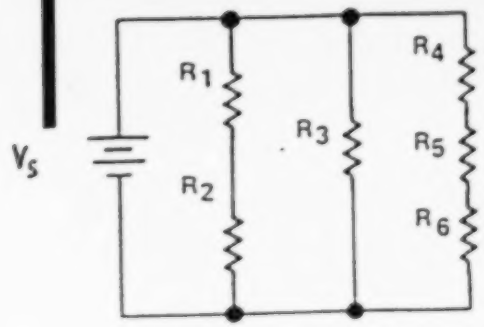


E	I	R
E_{R1}	I_{R1} 1.5A	R_1
E_{R2}	I_{R2}	R_2 60Ω
E_{R3} 145V	I_{R3}	R_3 50Ω
E_{R4} 20V	I_{R4}	R_4
E_{R5}	I_{R5} .5A	R_5
E_{R6}	I_{R6}	R_6 50Ω
E_T	I_T	R_T

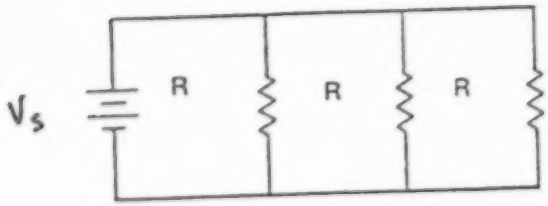


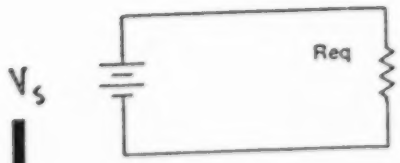


Practice Problems

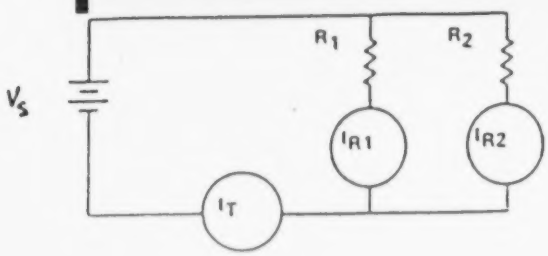


E	I	R
E_{R1}	I_{R1}	R_1 20Ω
E_{R2}	I_{R2}	R_2 30Ω
E_{R3}	I_{R3}	R_3 100Ω
E_{R4}	I_{R4}	R_4 40Ω
E_{R5}	I_{R5}	R_5 100Ω
E_{R6}	I_{R6}	R_6 60Ω
E_T 120V	I_T	R_T

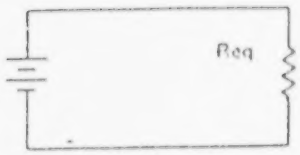


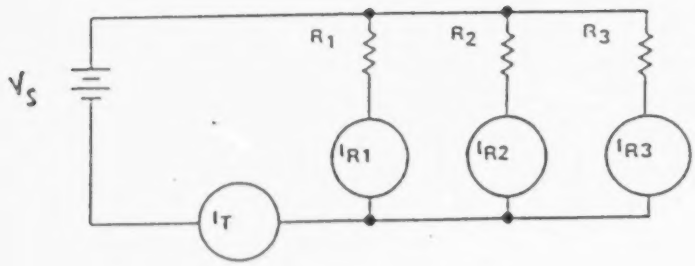


Practice Problems

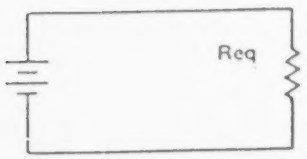


Branch	E	I	R
1			200Ω
2			100Ω
Total		1.2A	

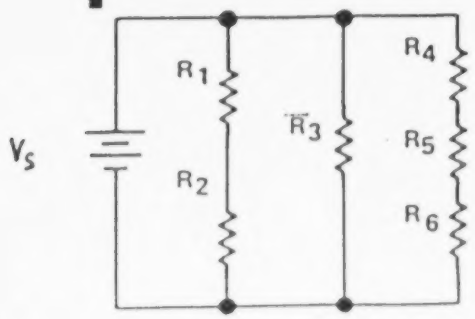




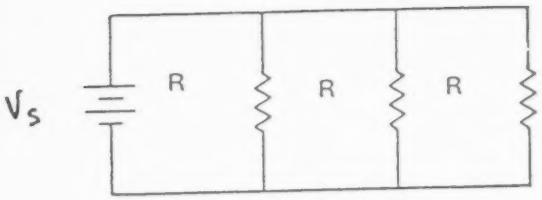
Branch	E	I	R
1		3.5A	
2			45Ω
3	90V	4.5A	
Total			

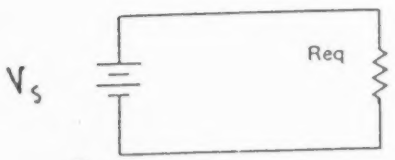


Practice Problems



E	I	R
E_{R1}	I_{R1}	R_1 1KΩ
E_{R2}	I_{R2}	R_2 2KΩ
E_{R3} 90V	I_{R3}	R_3 3KΩ
E_{R4}	I_{R4}	R_4 500Ω
E_{R5}	I_{R5}	R_5 470Ω
E_{R6}	I_{R6}	R_6 1.5KΩ
E_T	I_T	R_T





Your Notes

Series & Parallel Circuits

Series	Parallel
Current the same in all components	Voltage the same across all branches
V across each series R is $I \times R$	I in each branch R is V/R
$V_T = V_1 + V_2 + V_3 + \cdots +$ etc.	$I_T = I_1 + I_2 + I_3 + \cdots +$ etc.
$R_T = R_1 + R_2 + R_3 + \cdots +$ etc.	$G_T = G_1 + G_2 + G_3 + \cdots +$ etc.
R_T must be more than the largest individual R	R_{EQ} must be less than the smallest branch R
$P_T = P_1 + P_2 + P_3 + \cdots +$ etc.	$P_T = P_1 + P_2 + P_3 + \cdots +$ etc.
Applied voltage is divided into IR voltage drops	Main-line current is divided into branch currents
The largest IR drop is across the largest series R	The largest branch I is in the smallest parallel R
Open in one component causes entire circuit to be open	Open in one branch does not prevent I in other branches